

Estimating Canopy Dark Respiration for Crop Models

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Crop Models

- Crop production is obtained from accurate estimates of daily carbon gain.
- Canopy gross photosynthesis (P_{gross}) can be estimated from biochemical models of photosynthesis using sun and shaded leaf portions and the amount of intercepted photosynthetically active radiation (PAR).
- In turn, canopy daily net carbon gain can be estimated from canopy daily gross photosynthesis when canopy dark respiration (R_d) is known.

Crop Respiration

- Respiration in living cells allows for the controlled oxidation of carbohydrates and other substances, so that much of the energy can be retained in a useable form, such as ATP.
- aerobic respiration – (glycolysis, the Krebs cycle, and the ETR).
 - **$6 \text{C}_6\text{H}_{12}\text{O}_6 + 6 \text{O}_2 \rightarrow 6 \text{CO}_2 + 6 \text{H}_2\text{O} + \text{energy}$**

Crop Respiration

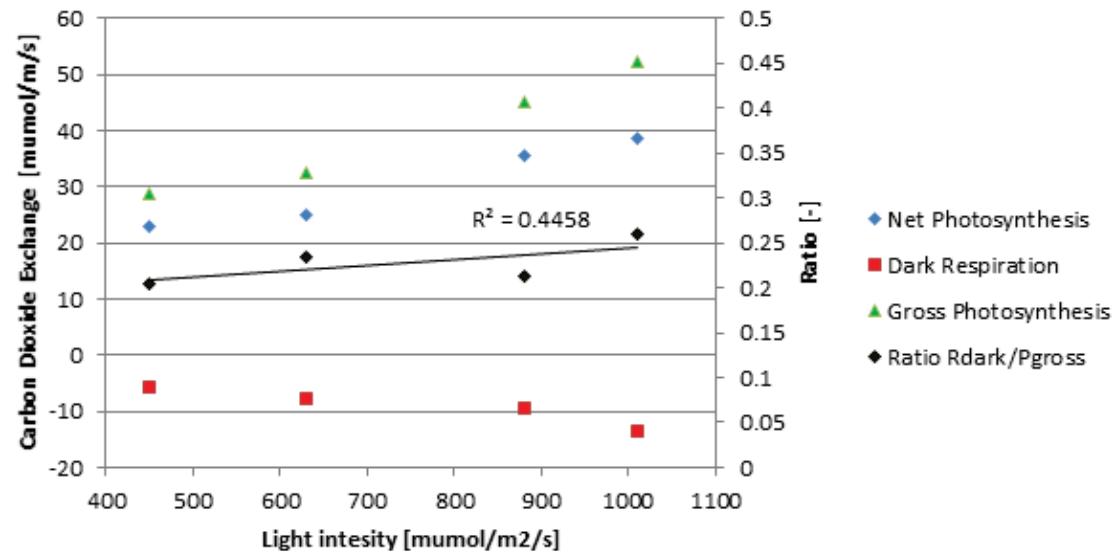
- Respiration is difficult to estimate and several methods have been developed:
 - growth and maintenance
 - nitrogen content
- Measurements of respiration using $^{13}\text{CO}_2$ indicate that dark respiration is proportional to gross photosynthesis.

Empirical Approach: R_d/P_{gross} ratio

- Using a constant R_d/P_{gross} ratio can simplify crop models estimating canopy-scale daily carbon gain.
- Dark respiration has been assumed to be a constant fraction of P_{gross} (Monteith 1977):
 - $R_d / P_{\text{gross}} = 0.4$
- $P_{\text{net}} = 0.6 * P_{\text{gross}} = 0.6 * \text{RUE} * \text{APAR}$
 - RUE = Radiation Use Efficiency
 - APAR = Absorbed PAR

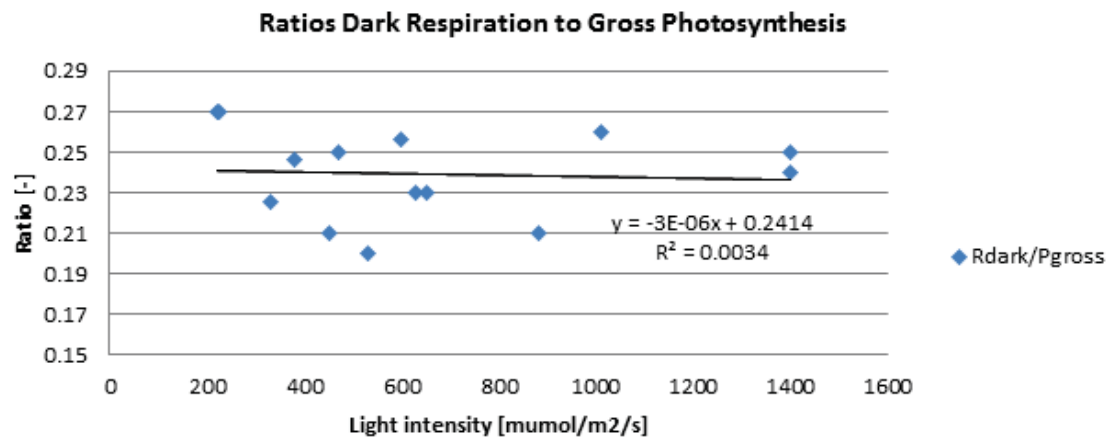
Does R_d/P_{gross} Vary with Light Intensity?

- The effect of light intensity (450, 630, 880, and 1010 $\mu\text{mol m}^{-2} \text{s}^{-1}$) on R_d/P_{gross} of pepper plants was measured at a constant CO_2 concentration.



Does [CO₂] affect Rd/Pgross ?

- Several datasets including high CO₂ concentrations (330 to 1300 ppm) were analyzed: pepper (this study), wheat (Monje et al. 1998), tomato and lettuce (Frantz et al. 2005). A mean canopy level Rd_{dark}/P_{gross} is 0.242 for C₃ plants and the ratio is independent of light intensity and CO₂ concentration.



Conclusion

- A gas exchange system was used to measure the effect of increasing light levels on the canopy level ratio of respiration to gross photosynthesis.
- A mean canopy level $R_{\text{dark}}/P_{\text{gross}}$ is 0.242 for C3 plants, which is roughly half of that observed for the leaf level.
- The $R_{\text{dark}}/P_{\text{gross}}$ ratio was found to be independent of light intensity and CO₂ concentration.
- These properties make the $R_{\text{dark}}/P_{\text{gross}}$ a suitable approach for simplifying crop models for estimating daily carbon gain.